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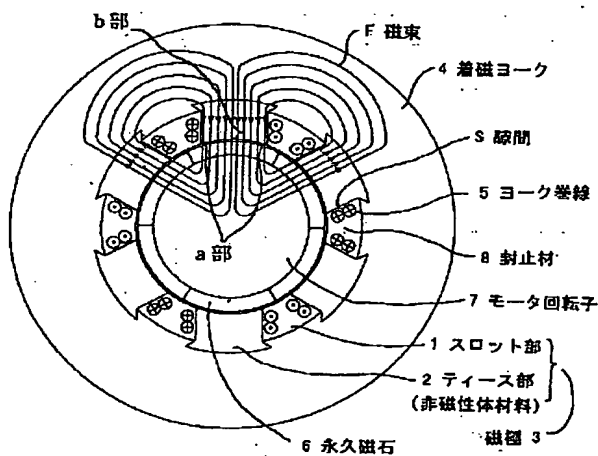
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(54) 【発明の名称】 回転子磁石の着磁装置

(57) 【要約】

【課題】 高調波を含まない起磁力分布や無負荷誘起電圧波形を得ることができる永久磁石同期モータにおける回転子磁石の着磁装置を提供する。

【解決手段】 円周方向に等間隔に設けた複数のティース部2とこのティース部2間に形成された開口部を有するスロット部1とよりなる磁極3を有する円筒状の着磁ヨーク4と、この着磁ヨーク4のスロット部1内に巻回された磁界を発生させるヨーク巻線5とを備え、ヨーク巻線5に通電して着磁ヨーク4の各磁極面の内側に空隙を介して対向配置される永久磁石6を着磁する回転子磁石の着磁装置において、永久磁石6に対面する着磁ヨーク4のティース部2を、非磁性体材料で構成したものである。



## 【特許請求の範囲】

【請求項 1】円周方向に等間隔に設けた複数のティース部とこのティース部間に形成された開口したスロット部とで構成される磁極を有する円筒状の着磁ヨークと、この着磁ヨークのスロット部内に巻回された磁界を発生させるヨーク巻線とを備え、前記ヨーク巻線に通電して前記着磁ヨークの各磁極面の内側に空隙を介して対向配置される回転子磁石を着磁する回転子磁石の着磁装置において、前記着磁ヨークのティース部を、非磁性体材料で構成したことを特徴とする回転子磁石の着磁装置。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、トルク脈動、回転リップルの少ない滑らかな動作を追求した永久磁石同期モータに用いられる回転子磁石の着磁装置に関するものである。

## 【0002】

【従来の技術】従来、回転子磁石の着磁装置は図 3 のようになっている。着磁装置は、希土類永久磁石を回転子表面に貼着した 6 極 9 スロット型の永久磁石同期モータに適用した例を示している。図において、1 は後述する着磁ヨークのティース部間に設けられ、内周に開口したスロット部、2 は着磁ヨークの内側の周方向に等間隔に設けられたティース部、3 はスロット部 1 とティース部 2 で構成された磁極、4 は円筒状の着磁ヨーク、5 はスロット部 1 内に巻回された磁界を発生させるヨーク巻線、6 は後述するモータ回転子の表面に貼着された永久磁石、7 は着磁ヨーク 4 の各磁極面の内側に空隙を介して設けたモータ回転子、8 はヨーク巻線 5 の間に充填された封止材である。このような構成において、ヨーク巻線 5 に通電して永久磁石 6 に着磁するようにしている。永久磁石 6 はその種類により異なるが、一般に 100 % の磁化を得るために 10 ~ 30 kOe の着磁界が必要であり、これを着磁ヨーク 4 のコイル起磁力から得ている。着磁ヨーク 4 の磁路は、コイル起磁力による磁束 F を通しやすくするため磁性体で構成するが、この従来例で示した希土類磁石のように高い着磁界が必要な永久磁石 6 を着磁する場合には 20 kOe 以上の大きなコイル起磁力が必要になり、着磁ヨーク 4 の磁路、特に永久磁石 6 と対面したティース部 2 が磁気飽和してしまう。この場合、ティース部 2 は磁性体でありながら磁気的な壁となり、磁束 F は主にスロット部 1 内のヨーク巻線 5 とティース部 2 のわずかな磁気的な隙間 S を通り、ティース部 2 先端の両端近傍と対向する空隙部 (a 部) をもとに永久磁石 5 を着磁することになり、a 部と対向したティース部の両端部分は着磁界が大きく逆にティース部 2 の中央の b 部は小さくなる。その結果として、永久磁石 6 の起磁力分布が図 4 の w 部で示すとおり 5、7 次高調波を多く含んだ凹形の台形波状になり、モータの無負荷誘起電圧波形も図 4 のように高調波を含んだ波形になっ

てしまう (何れもスキュー無し)、すなわち、トルク脈動、回転リップルの大きいモータとなって滑らかな運転が難しくなる。このような不具合を改善するため一般に永久磁石にスキュー着磁を施行し、図 5 のように無負荷誘起電圧波形を正弦波に近付けるようにしている。

## 【0003】

【発明が解決しようとする課題】ところが、従来技術では希土類磁石のように高い着磁界が必要な永久磁石を着磁する場合において、着磁ヨークの磁路、特にティース部が磁気飽和し、永久磁石の起磁力分布が高調波を多く含んだ凹形の台形波状になり、また、無負荷誘起電圧波形も高調波を多く含み、トルク脈動が増加するという問題があった。そこで本発明は、着磁ヨークのうちティース部の磁気飽和がなく、高調波を含まない起磁力分布や無負荷誘起電圧波形を得ることができる回転子磁石の着磁装置を提供することを目的とする。

## 【0004】

【課題を解決するための手段】上記問題を解決するために、本発明は、円周方向に等間隔に設けた複数のティース部とこのティース部間に形成された開口したスロット部とで構成される磁極を有する円筒状の着磁ヨークと、この着磁ヨークのスロット部内に巻回された磁界を発生させるヨーク巻線とを備え、前記ヨーク巻線に通電して前記着磁ヨークの各磁極面の内側に空隙を介して対向配置される回転子磁石を着磁する回転子磁石の着磁装置において、前記着磁ヨークのティース部を、非磁性体材料で構成したものである。上記手段により、希土類磁石のように高い着磁界が必要な永久磁石を着磁する場合でもティース部分が非磁性体であるため磁気飽和が避けられティース断面中の磁束密度が均等になる。そのため、永久磁石のティース対面部を平均的に着磁することになり、その結果、永久磁石の起磁力分布が 5、7 次高調波の少ない凹形の台形波状になり、モータの無負荷誘起電圧波形も正弦波に近い波形を得ることができる。

## 【0005】

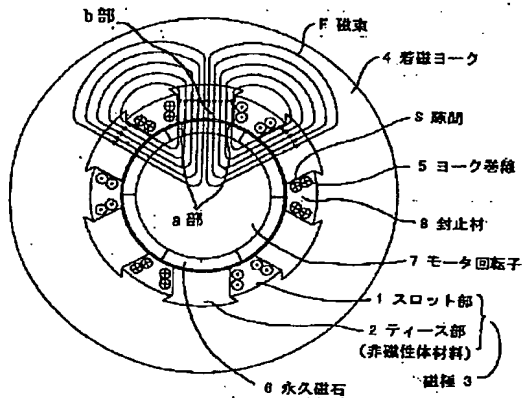
【発明の実施の形態】以下、本発明の具体的実施例を図に基づいて説明する。図 1 は、本発明の実施例を示す断面図であって、回転子磁石の着磁装置である。図 2 は、永久磁石の起磁力分布およびモータの無負荷誘起電圧波形を示す。本発明が従来技術と異なる特徴は、ティース部 2 を非磁性体材料で構成している点である。この非磁性体材料は、ヨーク巻線 5 を十分保持でき、しかも熱伝導率が高くかつ電気伝導率の小さい材料であれば特に限定されないが、例えば、高熱伝導率のエポキシ樹脂などが好ましい。このような構成における着磁作用を説明する。非磁性体材料からなるティース部 2 は、着磁ヨーク 4 と永久磁石 6 間に挟まれた磁路を構成するため若干磁気降下は大きくなるものの、コイル起磁力が過大でも磁束 F が飽和することは避けられ、ティース部 2 の断面中の磁束 F の流れも均等になる。そのため永久磁石 6 の a

部からb部を均等に着磁することになる。その結果として永久磁石1の起磁力分布は、図2のように5、7、11、・・・次高調波の少ない台形波状になり、モータの無負荷誘起電圧波形つまりトルク定数波形も高調波の少ない正弦波に近い波形を得ることができる。更に従来技術において図5のようにスキュー着磁をし無負荷誘起電圧波形を正弦波に近付けた場合と比較すると、ピーク値が10パーセント程度増加しモータの基本性能も向上する。したがって、回転子磁石の着磁装置は、着磁ヨークのうち、ティース部を非磁性体材料で構成したので、永久磁石のティース部との対向部分は磁気飽和がなくなって平均的に着磁できると共に、高調波を含まない起磁力分布や無負荷誘起電圧波形を得ることができる。また、ティース部が着磁ヨークと別部材のため、スロット内へのヨーク巻線の挿入および位置決めを容易にすることもできる。

#### 【0006】

【発明の効果】以上述べたように、本発明によれば、回転子磁石の着磁装置において、着磁ヨークのうちティース部を非磁性体材料で構成してあるので、ティース部の磁気飽和がなくなり、高調波を含まない起磁力分布や無負荷誘起電圧波形を得ることができるという効果があ

【図1】



る。

#### 【図面の簡単な説明】

【図1】本発明の実施例を示す断面図であって、回転子磁石の着磁装置である。

【図2】本発明の実施例を示す永久磁石の起磁力分布およびモータの無負荷誘起電圧波形である。

【図3】従来例を示す回転子磁石の着磁装置である。

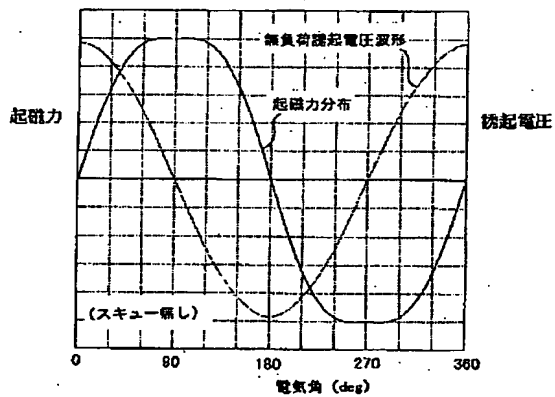
【図4】従来例を示す永久磁石の起磁力分布およびモータの無負荷誘起電圧波形である（スキューなし）。

10 【図5】従来例を示す永久磁石の起磁力分布およびモータの無負荷誘起電圧波形である（スキュー付き）。

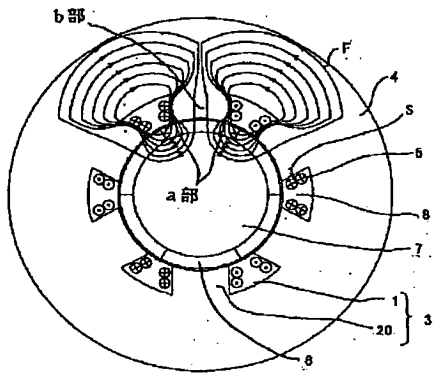
#### 【符号の説明】

- 1 スロット部
- 2 ティース部
- 3 磁極
- 4 着磁ヨーク
- 5 ヨーク巻線
- 6 永久磁石
- 7 モータ回転子
- 8 封止材
- F 磁束
- S 隙間

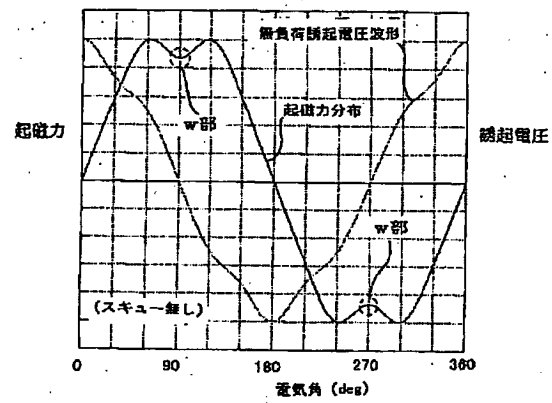
【図2】



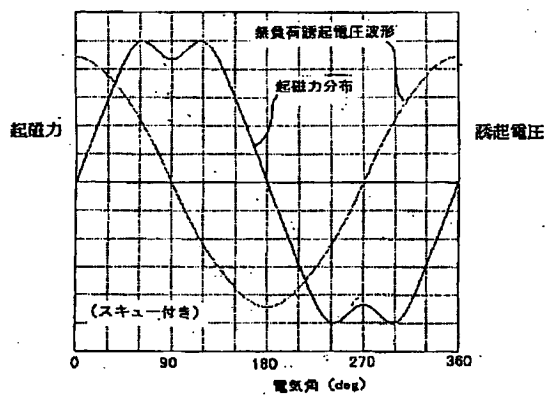
【図 3】



【図 4】



【図 5】



# PATENT ABSTRACTS OF JAPAN

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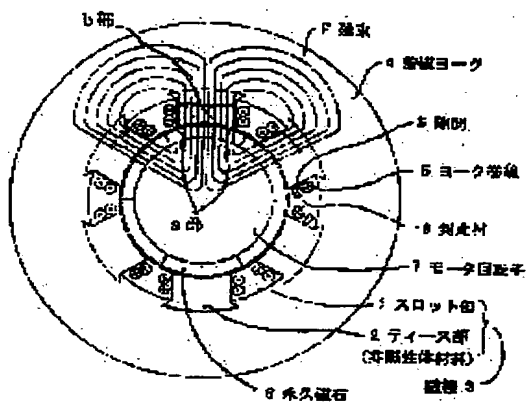
(22)Date of filing : 17.04.1998 (72)Inventor : KAWAKUBO HIROKI

## (54) MAGNETIZATION DEVICE OF ROTOR MAGNET

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a magnetization device of the rotor magnet of a permanent magnet synchronous motor by which a magnetomotive force distribution and a no-load induced voltage waveform which do not contain harmonic components can be obtained.

**SOLUTION:** This magnetization device for a rotor magnet has a cylindrical magnetization yoke 4 having a plurality of poles 3 composed of teeth 2 arranged in a circumferential direction with uniform intervals and slots 1 opened between the teeth 2 and yoke windings 5, which are wound in the slots 1 of the



magnetization yoke 4 and generate magnetic fields. Currents are applied to the yoke windings 5 to magnetize permanent magnets 6 which are provided inside the magnetization yoke 4 facing the inner surfaces of the respective poles with gaps therebetween. The teeth 2 of the magnetization yoke 4 which face the permanent magnets 6 are made of a nonmagnetic material.

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**[Claim(s)]**

[Claim 1] The magnetization yoke of the shape of a cylinder which has the magnetic pole which consists of two or more teeth sections prepared in the circumferential direction at equal intervals, and the slot section which was formed between this teeth section, and which carried out opening, It has the yoke coil which generates the field wound around the slot circles of this magnetization yoke. Magnetization equipment of the rotator magnet characterized by constituting the teeth section of said magnetization yoke from a non-magnetic-material ingredient in the magnetization equipment of the rotator magnet which magnetizes the rotator magnet by which energizes to said yoke coil and opposite arrangement is carried out through an opening inside each pole face of said magnetization yoke.

**[Detailed Description of the Invention]**

[0001]

[Field of the Invention] This invention relates to the magnetization equipment of the rotator magnet used for the permanent magnet synchronous motor which pursued torque pulsation and little smooth actuation of a revolution ripple.

[0002]

[Description of the Prior Art] Conventionally, the magnetization equipment of a rotator magnet has become like drawing 3 , and magnetization equipment shows the example applied to the permanent magnet synchronous motor of the 6 pole 9 slot mold which stuck the rare earth permanent magnet on the rotator front face. The slot section which 1 was prepared between the teeth sections of the magnetization yoke mentioned later in drawing, and carried out opening to inner circumference, The teeth section by which 2 was prepared at equal intervals in the hoop direction inside a magnetization yoke, the magnetic pole by which 3 was constituted from the slot section 1 and the teeth section 2, The yoke coil which generates the field by which 4 was wound around the cylinder-like magnetization yoke and 5 was wound in the slot section 1, The permanent magnet stuck on the front face of the motor rotator which 6 mentions later, the motor rotator which

prepared 7 through the opening inside each pole face of the magnetization yoke 4, and 8 are the sealing agents with which it filled up between the yoke coils 5. He energizes to the yoke coil 5 and is trying to magnetize to a permanent magnet 6 in such a configuration. Although a permanent magnet 6 changes with the classes, in order to obtain 100% of magnetization generally, the magnetization community of 10-30kOe is required, and this has been obtained from the coil magnetomotive force of the magnetization yoke 4. Although the magnetic path of the magnetization yoke 4 is constituted from the magnetic substance in order that it may be [ the magnetic flux  $F$  by coil magnetomotive force ] through-easy and may carry out it, when magnetizing the permanent magnet 6 which needs a high magnetization community like the rare earth magnet shown in this conventional example, the big coil magnetomotive force of 20 or more kOes will be needed, and the teeth section 2 which met the magnetic path of the magnetization yoke 4, especially the permanent magnet 6 will carry out magnetic saturation of it. The teeth section 2 serves as a magnetic wall, though it is the magnetic substance. Magnetic flux  $F$  the yoke coil 5 in the slot section 1, and few magnetic clearances  $S$  between the teeth sections 2 mainly In this case, a passage, A permanent magnet 5 will be magnetized based on the opening section (a section) near the ends at teeth section 2 head which counters, and the b section of the center of the teeth section 2 becomes [ a magnetization community ] large [ the ends parts of the a section and the teeth section which countered ] small at reverse. the concave trapezoid which included many 5 or 7th higher harmonics as the result as magnetomotive-force distribution of a permanent magnet 6 showed in the w section of drawing 4 -- it becomes wavelike and the no-load induced voltage wave of a motor also turns into a wave which included the higher harmonic like drawing 4 (all have no skew) -- that is, it becomes the large motor of torque pulsation and a revolution ripple, and smooth operation becomes difficult. In order to improve such nonconformity, generally skew magnetization is enforced to a permanent magnet, and he is trying to bring a no-load induced voltage wave close to a sine wave like drawing 5 .

[0003]

[Problem(s) to be Solved by the Invention] However, with the conventional technique, when the permanent magnet which needs a high magnetization community was magnetized like a rare earth magnet, the magnetic path, especially the teeth section of a magnetization yoke carried out magnetic saturation, and it became the concave shape of a trapezoidal wave in which magnetomotive-force distribution of a permanent magnet included many higher harmonics, and there was a problem that torque pulsation also increased a no-load induced voltage wave, including a higher harmonic mostly. Then,

this invention does not have the magnetic saturation of the teeth section among magnetization yokes, and aims at offering the magnetization equipment of the rotator magnet which can acquire the magnetomotive-force distribution which does not include a higher harmonic, and a no-load induced voltage wave.

[0004]

[Means for Solving the Problem] The magnetization yoke of the shape of a cylinder which has the magnetic pole which consists of two or more teeth sections which prepared this invention in the circumferencial direction at equal intervals in order to solve the above-mentioned problem, and the slot section which was formed between this teeth section, and which carried out opening, It has the yoke coil which generates the field wound around the slot circles of this magnetization yoke. In the magnetization equipment of the rotator magnet which magnetizes the rotator magnet by which energizes to said yoke coil and opposite arrangement is carried out through an opening inside each pole face of said magnetization yoke, the teeth section of said magnetization yoke consists of non-magnetic-material ingredients. With the above-mentioned means, since a teeth part is non-magnetic material even when magnetizing the permanent magnet which needs a high magnetization community like a rare earth magnet, magnetic saturation is avoided and the flux density in a teeth cross section becomes equal. Therefore, the teeth pair surface part of a permanent magnet will be magnetized on the average, consequently magnetomotive-force distribution of a permanent magnet becomes the shape of a trapezoidal wave with little 5 or 7th higher harmonic, and the no-load induced voltage wave of a motor can also obtain a substantially sinusoidal waveform.

[0005]

[Embodiment of the Invention] Hereafter, the concrete example of this invention is explained based on drawing. Drawing 1 is the sectional view showing the example of this invention, and is magnetization equipment of a rotator magnet. Drawing 2 shows magnetomotive-force distribution of a permanent magnet and the no-load induced voltage wave of a motor. The description with which this invention differs from the conventional technique is a point which constitutes the teeth section 2 from a non-magnetic-material ingredient. Although this non-magnetic-material ingredient can hold the yoke coil 5 enough, and it moreover will not be limited especially if thermal conductivity is a high ingredient with small conductivity, its epoxy resin of high temperature conductivity etc. is desirable, for example. The magnetization operation in such a configuration is explained. Since the magnetic path inserted between the magnetization yoke 4 and the permanent magnet 6 is constituted, although a magnetic

drop becomes large a little, even when the teeth section 2 which consists of a non-magnetic-material ingredient has excessive coil magnetomotive force, it is avoided that magnetic flux  $F$  is saturated and the flow of the magnetic flux  $F$  in the cross section of the teeth section 2 also becomes equal. Therefore, the b section will be uniformly magnetized from the a section of a permanent magnet 6. as the result -- magnetomotive-force distribution of a permanent magnet 1 -- drawing 2 -- like -- 5, 7, 11, and ... a trapezoid with little degree higher harmonic -- it becomes wavelike and little substantially sinusoidal waveform of a higher harmonic can be obtained, the no-load induced voltage wave, i.e., the torque constant wave, of a motor. Furthermore, as compared with the case where carried out skew magnetization like drawing 5 in the conventional technique, and a no-load induced voltage wave is brought close to a sine wave, peak value increases about 10% and basic engine performance's of a motor improves. Therefore, since the magnetization equipment of a rotator magnet constituted the teeth section from a non-magnetic-material ingredient among magnetization yokes, it can acquire the magnetomotive-force distribution and the no-load induced voltage wave which do not include a higher harmonic while the magnetic saturation of the opposite part with the teeth section of a permanent magnet is lost and being able to magnetize it on the average. Moreover, since the teeth sections are a magnetization yoke and another member, insertion and positioning of a yoke coil into a slot can also be made easy.

[0006]

[Effect of the Invention] Since the teeth section is constituted from a non-magnetic-material ingredient among magnetization yokes in the magnetization equipment of a rotator magnet according to this invention as stated above, the magnetic saturation of the teeth section is lost and it is effective in the ability to acquire the magnetomotive-force distribution and the no-load induced voltage wave which do not include a higher harmonic.

[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing the example of this invention, and is magnetization equipment of a rotator magnet.

[Drawing 2] They are magnetomotive-force distribution of the permanent magnet in which the example of this invention is shown, and the no-load induced voltage wave of a motor.

[Drawing 3] It is magnetization equipment of the rotator magnet in which the conventional example is shown.

[Drawing 4] They are magnetomotive-force distribution of the permanent magnet in which the conventional example is shown, and the no-load induced voltage wave of a motor (with no skew).

[Drawing 5] They are magnetomotive-force distribution of the permanent magnet in which the conventional example is shown, and the no-load induced voltage wave of a motor (with a skew).

[Description of Notations]

1 Slot Section

2 Teeth Section

3 Magnetic Pole

4 Magnetization Yoke

5 Yoke Coil

6 Permanent Magnet

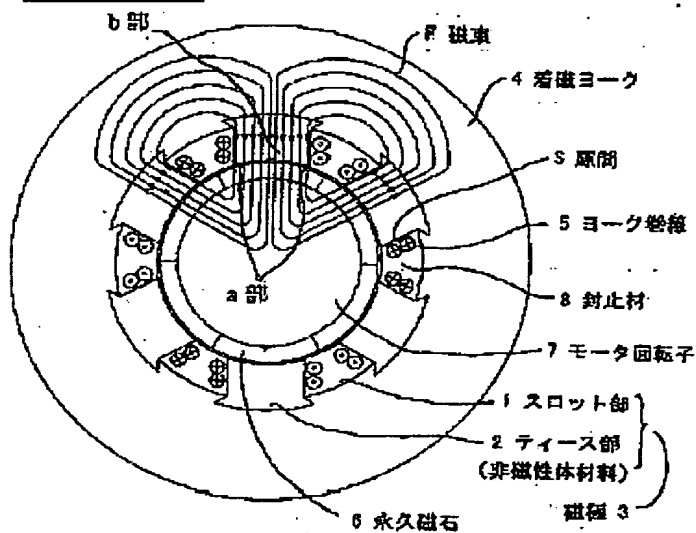
7 Motor Rotator

8 Sealing Agent

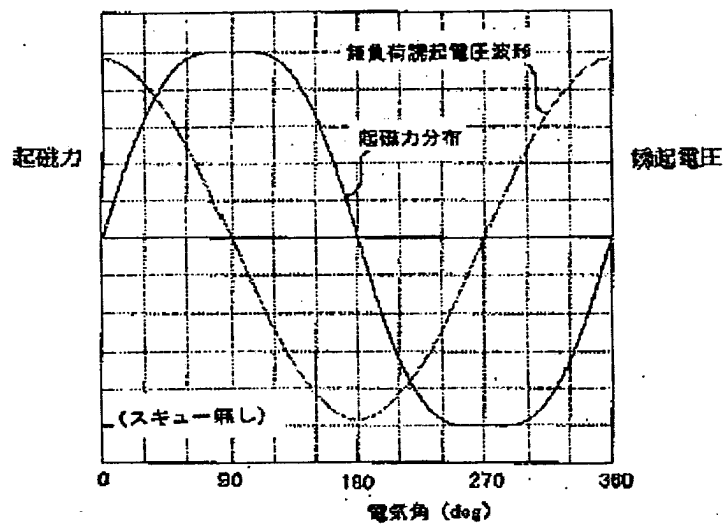
F Magnetic flux

S Clearance

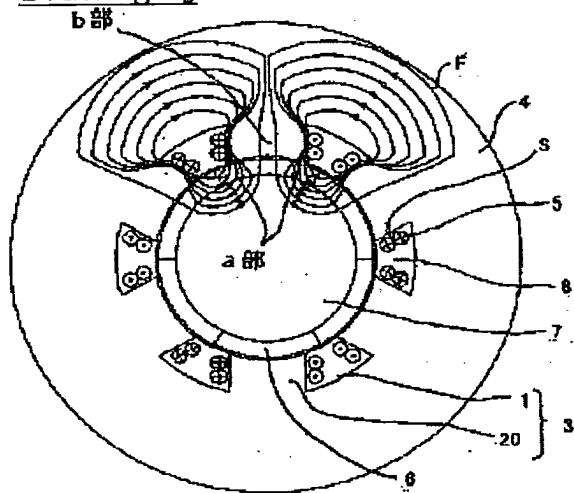
Drawing 1]



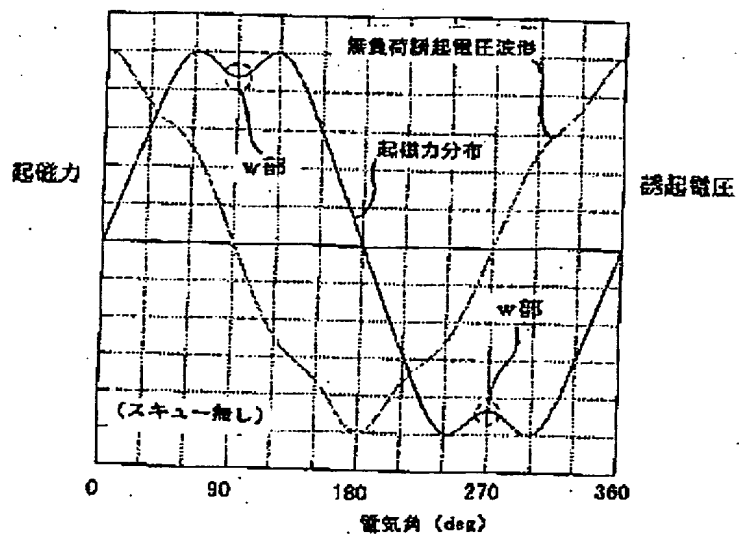
Drawing 2]



Drawing 3]



Drawing 4]



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